# PERFORMANCE AND EMISSION ANALYSIS OF DIESEL ENGINE BY USING NON EDIBLE BIODIESEL

*A project report submitted in partial fulfillment of the requirements for the award of the Degree of*

**BACHELOR OF TECHNOLOGY**

In

**MECHANICAL ENGINEERING**

***By***


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# DECLARATION

We hereby declare that the project entitled “PERFORMANCE AND EMISSION ANALYSIS OF DIESEL ENGINE BY USING NON-EDIBLE BIODIESEL” in partial fulfilment of requirements for the award of degree of Bachelor of Technology in Mechanical Engineering to ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES is an authentic work and has not been submitted to any other university /Institute for the award of any degree/diploma.

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# ABSTRACT

The pollution in our country is increasing day by day and day to day consumption of fossil fuels are increasing and the cost of diesel is also increasing .So the world is looking for fuels which releases less harmful gases. Majority of the pollution today is due to emission of gases like (HC, CO, $CO_2$, $NO_x$) are from automobiles. So we thought of reducing this pollution by using biodiesel.

Biodiesel is eco-friendly oil which releases less carbon dioxide than diesel and the cost of biodiesel when compared with diesel is same or low. So, that the automobiles may use this oil comfortable and the effects of pollution will also be reduced. In this research work, biodiesel was prepared from Mahua oil. Expeller method was employed to extract mahua oil from its seed and it was subjected to two stage Transesterification due to presence of more than 18% free fatty acid content after preparing the mahua biodiesel the blends of mahua methyl ester and diesel in the proportion of B5, B10 and B20were prepared analysed and their performance and emission parameters are compared with performance characteristics like fuel consumption, Brake specific fuel consumption, Brake thermal efficiency, etc.,. And emission characteristics like CO, $CO_2$, HC and $NO_X$.

# CHAPTER 1

# INTRODUCTION

# INTRODUCTION

## 1.1 FOSSIL FUEL

The term fossil is used to describe the broad set of fuels “formed in the Earth from plant or in the earth from plant or animal remains” that have been transformed into raw energy sources over the course of many years as a result of geological processes. In effect, fossil fuels are the repositories of millions of years of energy that has been accumulated and shaped into a concentrated form.

Fossil fuels come in three main forms: petroleum, or crude oil, coal; and natural gas. All have many uses, but each serves one main purpose. In 2011, fossil fuels accounted for approximately 82 percent of world’s primary energy use but this is expected to fall to 78 percent by 2040, meaning that the use of fossil fuels is expected to be on a decline due to use of alternative fuels. Yet fossil fuels are finite resources and they can also irreparably harm the environment. According to Environmental Protection Agency, the burning of fossil fuels was responsible for 79 percent of U.S. greenhouse gas emissions in 2010. Oil is the world’s primary fuel source for transportation. Most oil is pumped out of underground reservoirs, but it can also be found imbedded in shale and tar sands. Once extracted, crude oil is processed in oil refineries to create fuel oil, gasoline, liquefied petroleum gas , and other non-fuel products such as pesticides ,fertilizers ,pharmaceuticals and plastics.

## 1.2 Alternative Fuels

Alternative fuels, known as non-conventional or advance fuels, are any materials or substances that can be used as fuels, other than conventional fuels. Some well-known alternative fuels include biodiesel, bio-alcohol (methanol, ethanol, butanol), chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non- fossil natural gas, vegetable oil, propane, oil from waste tyres and plastic, and other biomass sources.

These alternative fuels are economical when compared to diesel. So, these are most suitable for automobiles and they can meet the growing demand for fuels in the future.

## 1.3 Need for Shifting Towards Alternative Fuels

Probably in this century, it is believed that crude oil and petroleum products will become very scarce and costly to find and produce. Although fuel economy of engines is greatly improved, increase in the number of automobiles alone dictates that there will be a great demand for fuel in the near future. Alternative fuel technology, availability, and use must and will become more common in the coming decades. Another reason motivating the development of alternative fuels for the IC-engine is concerned over the emission problems of gasoline engines. Combined with air polluting systems, the large number of automobiles is a major contributor to the air quality problem of the world. A third reason for alternative fuel development is the fact that a large percentage of crude oil must be imported from other countries which control the larger oil fields.

## 1.4 Biodiesel

Biodiesel is a safe alternative fuel to replace traditional petroleum diesel. It has high-lubricity, is a clean-burning fuel and can be a fuel component for use in existing, unmodified diesel engines. This means that no retrofits are necessary when using biodiesel fuel in any diesel powered combustion engine. It is the only alternative fuel that offers such convenience. Biodiesel acts like petroleum diesel, but produces less air pollution, comes from renewable sources, is biodegradable and is safer for the environment. Producing biodiesel fuels can help create local economic revitalization and local environmental benefits. Many groups interested in promoting the use of biodiesel already exist at the local, state and national level.

## 1.5 History of Bio Diesel

Use of Bio diesel in Diesel engines is not a new concept but century old. In fact Rudolf Diesel, the inventor of the Diesel Engine just used Peanut oil in his engine as early as1901. But later on the cheap availability of petroleum diesel completely replaced the use of vegetable oil. Today, since the availability is becoming scarce, it will be wise to go back to the traditional natural fuels like vegetable oil Day-by-day the diesel oil is becoming costlier and dearer and within a few years it may not be available at all. Even now its availability is influenced by various extraneous factors like political situations, wars, terrorist activities etc. The worst affected are the developing countries like India, who do not have adequate resources of Petroleum products. To-day we import 70% of our crude oil and in the coming years the requirement will increase greatly. Of all the petroleum products diesel oil is the maximum Hence it is high time the world develops an alternate fuel devoid of all the above problems. Bio diesel fits the slot perfectly to replace Petroleum diesel. Bio diesel is nothing but processed vegetable oil or animal fats. The vegetable oil can be either edible or nonedible. Also used as cooking oil or fresh vegetable oil.

## 1.6 MAHUA (Madhuca long folia)

### 1.6.1 History of Plant

Mahua Scientifically named as Madhuca long folia is an Indian tropical tree found largely in the central and north Indian plains and forests. It is commonly known as mahua, mahua or Iluppai . It is a fast-growing tree that grows to approximately 20 meters in height, possesses evergreen or semi-evergreen foliage, and belongs to the family Sapotaceae. It is adapted to arid environments, being a prominent tree in tropical mixed deciduous forests in India in the states of West Bengal, Chhattisgarh, Jharkhand, Uttar Pradesh, Bihar, Maharashtra, Madhya Pradesh, Kerala, Gujarat and Orissa. It is cultivated in warm and humid regions for its oleaginous seeds (producing between 20 and 200 kg of seeds annually per tree, depending on maturity), flowers and wood. The fat (solid at ambient temperature) is used for the care of the skin, to manufacture soap or detergents, and as a vegetable butter. It can also be used as a fuel oil. The seed cakes obtained after extraction of oil constitute very good fertilizer. The flowers are used to produce an alcoholic drink in tropical India. This drink is also known to affect the animals. Several parts of the tree, including the bark, are used for their medicinal properties. It is considered holy by many tribal communities because of its usefulness.

The tree is considered a boon by the tribal s who are forest dwellers and keenly conserve this tree. However, conservation of this tree has been marginalized, as it is not favored by non tribal s. The leaves of Madhuca indica ( M. longifolia ) are fed on by the moth Antheraea paphia , which produces tassar silk ( tussah), a form of wild silk of commercial importance in India. The Tamils have several uses for M. longifolia (iluppai inTamil). The saying “aalai illaa oorukku iluppaip poo charkkarai “indicates when there is no cane sugar available, the flower of M. longifolia can be used, as it is very sweet. However, Tamil tradition cautions that excessive use of this flower will result in imbalance of thinking and may even lead to lunacy this is good for dog's hair. The alkaloids in the press cake of Madhuca seeds are reportedly used in killing fishes in aquaculture ponds in some parts of India. The cake serves to fertilize the pond, which can be drained, sun dried, refilled with water and restocked with fish fingerlings.

**1.6.2 Mahua Flower**

The mahua flower is edible and is a food item for tribal s. They are used to make syrup for medicinal purposes. They are also fermented to produce the alcoholic drink mahua, a country liquor. Tribal s of Bastar in Chhattisgarh and Orissa, Santhals of Santhal Paraganas(Jharkhand), Koya tribals of North-East Andhra Pradesh (vippa sara) and tribal s of North Maharashtra consider the tree and the mahua drink as part of their cultural heritage. Mahua is an essential drink for tribal men and women during celebrations. The main ingredients used for making it are chhowa gud (granular molasses) and dried mahua flowers. The liquor produced from the flowers is largely colour less, with a whitish tinge and not very strong. The taste is reminiscent of Sake with a distinctive smell of mahua flowers. It is inexpensive and the production is largely done in home stills. Mahua flowers are also used to manufacture jam, which is being made by tribal cooperatives in the Gadchiroli district of Maharashtra.

**Fig:1.1 Mahua Flowers**

**1.6.3 Other botanical names of mahua flower**

1. Bassia longifolia L.

2. B. latifolia Roxb.,

3. Madhuca indica J. F. Gmel.,

4. M. latifolia (Roxb.)

5. J.F.Macbr.,

6. Illipe latifolia (Roxb.) F.Muell.,

7. Illipe malabrorum (Engl.)

**1.6.4 Madhuca longifolia Scientific classification**

1. Kingdom: Plantae
2. Order: Ericales
3. Family: Sapotaceae
4. Genus: Madhuca
5. Species: M. longifolia
6. Binomial name: Madhuca longifolia

**Fig:1.2 MAHUA SEEDS**

## 1.7 Mahua Oil

The properties like high oiliness, viscosity and indices, higher flash points, less evaporative loss and low full accounting cost (includes operational and nature replenishment cost) are technical in nature which gives competitive edge and hence they are preferred even after some inferior traits like reduced oxidation and thermal stabilities, poor cold flow properties, lower shelf life, but researches are working on these parameters and can be improved by applying some modification in techniques and systematized research .There is large numbers of varieties in oil (Edible & Non Edible), only some are short listed as far as their potential is concern. Edible oils are used by all the population because of their food dependency, some non edible oils are also useful for food but mostly are not used and hence has low usage in food and hence low dependency as far as food parameter is concern that's why due to this only non edible oils could be utilized as alternative fuels having untapped potential and also multiply to the rural economy. Even after showing promising benefits very few attempts have been taken by previous researchers .

Non edible oils are the main source of making biodiesel in India and Mahua is taken as probable oil seed feed stock for the production of biodiesel. In India, we can find Mahua plant in many states like Orissa, Chattishgarh, Jharkhand, Bihar, Madhya Pradesh and Tamil Nadu and for getting successfully mature. It uses waste and dry land which is not at all useful for any kind of other vegetation. Its plant does not require any special or specific kind of attention as it is easily adaptable in any weather condition, resulting maximum height attains 20 m, wide spreading roots and branches along with circular crown & nice appealing structure. Fruits look like egg shaped berries and mature seeds can be drawn from June to July .

Moving ahead to its plantation part, its tree have been very useful in Indian economy, mostly carries the rural one. Season of flower ranges from February to April, rich in sugar content (73%) just next to cane molasses. It also carries basic raw material for alcohol fermentation and its dried flower carries 450 liters of alcohol yield. 50 % of oil contained by kernel of mahua fruit and its fresh oil is yellow in color where as its commercial oil is normally greenish yellow in color. The mahua tree takes 8 to 15 years to become mature and can draw fruits up to 60 years of age.

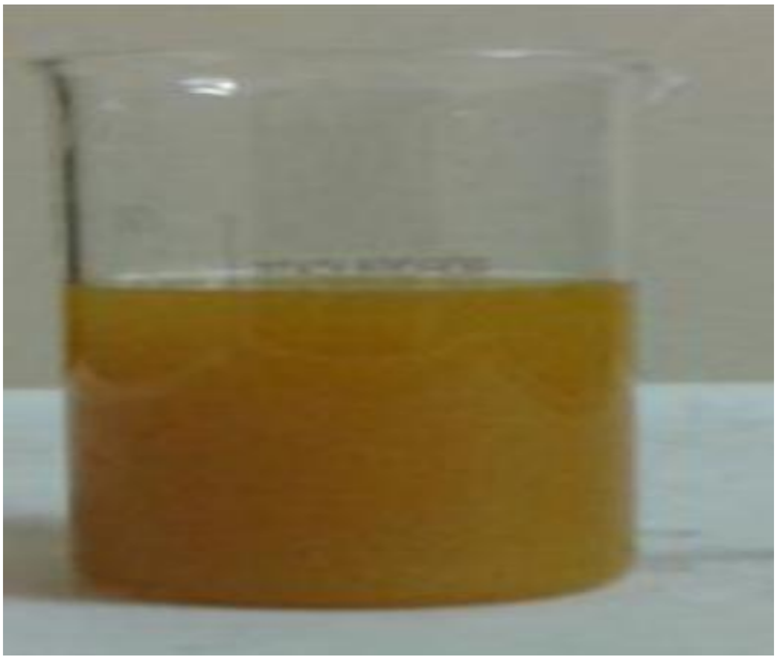

**Fig: 1.3 MAHUA OIL**

As discussed it has highly spreaded roots which with holds the soil and all these happens on waste land which helps our rural people to grow along with national economy

## 1.8 MAHUA AS FUEL

As far as Mahua's fuel property are concerned it is comparable with diesel fuel and is available in good quantities that too underutilized. Its calorific value is 96.30% on volume basis of diesel. It does not have any significant change if we mix mahua oil by 20% in diesel in terms of power output, brake specific fuel consumption and brake thermal efficiency. By using mahua oil blends, performance of engine improved which enhance compression ratio from 16:1 to 20:1. With above results it is found that mahua oil can be treated as substitute of diesel but with proper care and can show profitability when it could be taken to large scale production. Stage wise concern is required like in sowing season along with latest agro techniques, proper pest control and post harvesting management.

**Table 1.1.Characteristics of Fat**

| S. No | Characters | Characteristic / valve |
|---|---|---|
| 1 | Colors | Pale Yellow |
| 2 | Consistency | Plastic |
| 3 | Refractive Index at 40 degree | C1.451 to 1.463 |
| 4 | Specific gravity at 15 degree | C 0.857 to 0.871 |
| 5 | Iodine valve | 58.00 to 70.00 |
| 6 | Specification valve | 188 to 195 |
| 7 | Un specification valve | 1.00 to 3.00 |

**Table:1.2 Properties of mahua oil**

| Properties | Diesel | Mahua oil |
|---|---|---|
| Density | 850 | 960 |
| Viscosity(cSt)at40$^{o}$C | 4.59 | 24.6 |
| Flash point($^{o}$C) | 68 | 232 |
| Pour point($^{o}$C) | 15 | -20 |
| Water content(%) | 1.6 | 0.02 |
| Ash content(%) | 0.9 | 0.01 |
| Cetane number | 45 | 46 |

# CHAPTER 2

# LITERATURE REVIEW

# LITERATURE REVIEW

K.Anbumani and ajit pal singh observed the feasibility of using two edible plant oils mustard and neem as diesel substitute a comparative study on their combustion characteristics on a C.I. Engine were made oils were esterified before with pure diesel in the ratio of 10:90,15:85,20:80and 25:75by volume .Pure diesel is used as control studies have related that on blending vegetable oils with diesel a remarkable improvement in their physical and chemical properties was observed .These studies have revealed that both the oils at 20% blend with diesel can be used as a diesel substitute.

MK Ghosal, DK Das , SC Pardhan and N Sahoo. " performance study of diesel engine by using mahua methyl ester and it is blended with diesel fuel. Agriculture Engineering International: The CIGRE journal manuscript ee08

Chatpalliwarletal described the brief overview of the Biodiesel production plant.Various issues-sources, opportunities, challenges, plant design and evolution etc, are discussed related to the biodiesel production. The contribution of the work is that it discusses the important issues concerned with the Biodiesel production plant design the fundamental details required for the formulation of Biodiesel plant and also it presents possible approach for the mathematical model to evaluate the biodiesel plant.

Md.ImranKaisetal research focused on algae cultivation.A lab scale production of Chlorella and Botroyococcusbraunii was executed in open pond and Bioreactor system.Then diesel was produced by transesterification from collected algae oil.Later data was collected from this experiment.Cost analysis was prepared to get a clear concept of the actual scenario sof algae fuel probability.This study Indicates high potentiality of algae based fuel replacing diesel for energy production.It can be a model for any third world country to mitigate The energy crisis with a greener solution.

Saravanan et al (2010) conducted an experimental study on a single cylinder four stroke diesel engine with Mahua oil methyl ester as fuel. The experimental results showed a power loss around 13% and 20% increase in fuel consumption with Mahua oil methyl ester. Carbon monoxide and hydrocarbon emissions were found to be less than diesel by 26% and 20% respectively. NOx emission was less by 4% for the Mahua oil methyl ester when compared to diesel.

Godignur et al (2009) carried out an experimental investigation to study the performance and emission characteristics in a turbocharged direct injection compression ignition engine fuelled with diesel, Mahua oil biodiesel, and its blends. The outcome of the investigation showed that the increase of Mahua biodiesel in the blends reduced the carbon monoxide and hydrocarbon emission 47 remarkably. Fuel consumption and oxides of nitrogen (NOx) emission were increased when compared to diesel.

Puhan et al (2005) conducted an experimental investigation with mahua oil methyl ester with diesel fuel in a single cylinder direct injection diesel engine and showed a decrease of 13% in brake thermal efficiency. In the continual work they pointed out that the viscosity of mahua oil ethyl ester was slightly higher than that of mahua oil methyl ester.

# CHAPTER 3

# SYNTHESIS OF MAHUA OIL

### 3.1 Mahua Oil Extraction (Old Method)

There are many methods of extracting mahua oil now, but initially there are only few traditional methods. One of them is from Bihar Tribes.

In their method, The ripe mahua fruits which are shredded by Madhuca Indica itself, are taken and the peel of its skin is removed and then dried.After drying them, They crush them in to a powder which is boiled with the traditional water vapour technique, then that processed powder is wrapped up in a cloth which is kept between two wooden logs ,A Traditional Method found by Bihar Tribals themselves.

By pressing i.e; compressing the cloth with the processed powder between the the two wooden logs, they get the mahua oil from it.Thats how The Mahua Oil is extracted from the Madhuca Indica.

### 3.2 Mahua Yield

If we think biodiesel as the industry we have to face feed stock supply as top challenge because producers are looking for such type of non-food crop that too from non-agricultural land means with cheaper feed stock. It can also sustain in any type of weather conditions that means it is matching all the requirements of the market. Mahua will yield at Maturity as high as 3 tons oil with proper nutrition, and irrigation. This is totally an extraordinary amount of oil from an agricultural crop .

### 3.3 Advanced Methods For Extraction Of Mahua Oil

Mahua Oil extraction process can be done with or without seed coat; also if we choose appropriate and efficient oil extraction method, we can enhance the yield by more than 5%. Like in case of Jatropha, by using mechanical de hulling system so as to take out coat of seed, we can get 10 % increased yield. In cold pressing where temperature is less than 60°C, up to 88% and in hot pressing where temperature is 110 – 120°C, up to 90% efficiency is achieved. The solvent extraction method increases the efficiency till 99% but it carries disadvantage too, with the solvent extraction is that the quantity of phospholipids in solvent extracted oil is double as high as compared to pressed oil. It requires then a further step of oil de gumming before transesterification. Oil extraction methods are also being developed based on fermentation hydrolysis. In this process, cell walls of the oil plant seeds are destroyed followed by the release of the oil present within the cells.

### 3.4 Blending of Mahua Oil with Fossil Fuels

In this Analysis we use three types of blends B5,B10,B20 .In B5 Biodiesel ,950ml of diesel is mixed with 50 ml of Mahua Methyl Ester to give 1 litre of solution. In B10 Biodiesel ,900ml of diesel is mixed with 100 ml of Mahua Methyl Ester to give 1 litre of solution In B20 Biodiesel ,800ml of diesel is mixed with 200 ml of Mahua Methyl Ester to give 1 litre of solution.

**Table 3.1 Quantities of BioDiesl**

| S.No | Blend | Biodiesel (Milli Litres) | Diesel (Milli Litres) | Mahua Methyl Ester (Milli Litres) |
|---|---|---|---|---|
| 1 | B5 | 1000 | 950 | 50 |
| 2 | B10 | 1000 | 900 | 100 |
| 3 | B20 | 1000 | 800 | 200 |


**Fig:3.1 Biodiesel Blends**

# CHAPTER 4

# EXPERIMENTAL SETUP

# EXPERIMENTAL SETUP

## 4.1 Diesel Engine:

A diesel engine also known as a compression-ignition engine. It is an internal combustion engine that uses the heat of compression to initiate ignition to burn the fuel that has been injected into the combustion chamber. This is in contrast to spark-ignition engines such as a petrol engine, gasoline engine or gas engine using a gaseous fuel as opposed to gasoline, which uses a spark plug to ignite an air-fuel mixture. The engine was developed by German inventor Rudolf Diesel in 1893.

The diesel engine has the highest thermal efficiency of any regular internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines are used in ships and for other applications where overall engine weight is relatively unimportant, can have a thermal efficiency that exceeds 50%.

Diesel engines are manufactured in two-stroke and four-stroke versions. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s they have been used in submarines and ships. Its use in locomotives, trucks, heavy equipment and electric generating plants followed later. In the 1930s, they slowly began to be used in a few automobiles. Since the 1970s, the use of diesel engines in larger on-road and off-road vehicles in the USA increased. As of 2007, about 50% of all new car sales in Europe are diesel.

The world's largest diesel engine is currently a Wartsila-Sulzer RTA96-C Common Rail marine diesel of about 84,420 kW (113,210 HP) @ 102 rpm output. According to the British Society of Motor Manufacturing and Traders, the EU average for diesel cars account for 50% of the total sold, including in France 70%, and in the UK - 38%.

### 4.1.1 Size groups:

There are three size groups of Diesel engines.

- Small -Under 188 kW (252 HP) output
- Medium

- Large

### 4.1.2 Engine speeds:

Within the diesel engine industry, engines are often categorized by their rotational speeds into three groups:

- High-speed engines (>1,000 rpm),
- Medium-speed engines (300 - 1,000 rpm), and
- Slow-speed engines (<300 rpm).

High-speed and Medium-speed engines are predominantly four-stroke engines; except for the Detroit Diesel two-stroke range. Medium-speed engines are physically larger than high-speed engines and can burn lower-grade (slower-burning) fuel than high-speed engines.

Slow-speed engines are predominantly large two-stroke crosshead engines, hence very different from high- and medium-speed engines. Due to the lower rotational speed of slow-speed and medium-speed engines, there is more time for combustion during the power stroke of the cycle.

### 4.1.3 Major advantages:

Diesel engines have several advantages over other internal combustion engines:

They burn less fuel than a petrol engine performing the same work, due to the engine's higher temperature of combustion and greater expansion ratio. Gasoline engines are typically 30% efficient while diesel engines can convert over 45% of the fuel energy into mechanical energy.

They have no high voltage electrical ignition system, resulting in high reliability and easy adaptation to damp environments. The absence of coils, spark plug wires, etc., also eliminates a source of radio frequency emissions which can interfere with navigation and communication equipment, which is especially important in marine and aircraft applications.

The life of a diesel engine is generally about twice as long as that of petrol engine due to the increased strength of parts used. Diesel fuel has better lubrication properties than petrol as well.

Diesel fuel is distilled directly from petroleum. Distillation yields some gasoline, but the yield would be inadequate without catalytic reforming, which is a more costly process. Diesel fuel is considered safer than petrol in many applications. Although diesel fuel will burn in open air using a wick, it will not explode and does not release a large amount of flammable vapour. The low vapour pressure of diesel is especially advantageous in marine applications, where the accumulation of explosive fuel-air mixtures is a particular hazard. For the same reason, diesel engines are immune to vapour lock.

For any given partial load, the fuel efficiency (mass burned per energy produced) of a diesel engine remains nearly constant, as opposed to petrol and turbine engines which use proportionally more fuel with partial power outputs. They generate less waste heat in cooling and exhaust.

Diesel engines can accept super- or turbo-charging pressure without any natural limit, constrained only by the strength of engine components. This is unlike petrol engines, which inevitably suffer detonation at higher pressure.

The carbon monoxide content of the exhaust is minimum; therefore diesel engines are used in underground mines.

Biodiesel is easily synthesized, non-petroleum-based fuel (through transesterification) which can run directly in many diesel engines, while gasoline engines either need adaptation to run synthetic fuels or else use them as an additive to gasoline (e.g., ethanol added to gasohol).

**4.1.4Engine description:**

The prepared fuel blends are used in Kirloskar made Four stroke, single cylinder diesel engine- test rig in the laboratory and load test is held with additional attachment of muffler to the exhaust smoke pipe .By the load test, the performance characteristics and from smoke analysis, combustion analysis of fuel is obtained.

The given I.C engine is a vertical, single cylinder, 4-stroke, and water-cooled constant speed diesel engine. It is fitted with a flywheel sufficient enough to give momentum to absorb energy when in power stroke and release during the other three strokes to get a uniform speed. Provision is made to measure the exhaust heat with the help of a calorimeter and thermocouples fixed at salient points. This engine is provided with a crank handle for starting. The engine is mounted with an absorption thermometer of brake drum type. The engine set up is also provided with burette, graduations duly marked and a three way to measure the fuel flow rate.

Fig : 4.1 Four Stroke Vertical Diesel Engine With Brake drum Setup

### 4.1.5 Combustion in diesel engine

Combustion in diesel engines takes place in three distinct phases as shown in fig 4.5.

**First Phase of Combustion:**

Ignition delay period is the time span between commencement of fuel injection and the start of fuel ignition. The fuel emerges into the cylinder as small liquid particles, which are surrounded by hot compressed air. They receive heat from the air and more volatile constituents of the fuel vaporize. During the ignition delay period a large part of the fuel charge is prepared for combustion. During the ignition delay, the injector continued to inject the fuel and, if this has built up a sufficient quantity, the rapid combustion and pressure rise will be quite violent, causing detonation and shock loading creating a noise termed diesel knock. After ignition commences flame propagation proceeds very quickly in the fuel vapor or air mixture, accompanied by rapid temperature and pressure rise. Towards the end of the rapid pressure rise a point is reached where the rate of pressure rise falls away quickly, and the curve flattens out towards the maximum pressure point. The point where the rate of pressure rise changes near and approaching the maximum pressure point is the end of the second phase of combustion. This shows only a small pressure rise, as the rate is decreased due to downward movement of the piston. The end of injection occurs approximately at or slightly beyond the maximum pressure point. Combustion in diesel engines can be termed as a 'controlled explosion'.

**Second Phase of Combustion:**

Rapid or uncontrolled combustion usually occur just after the ignition of the fuel vapors.

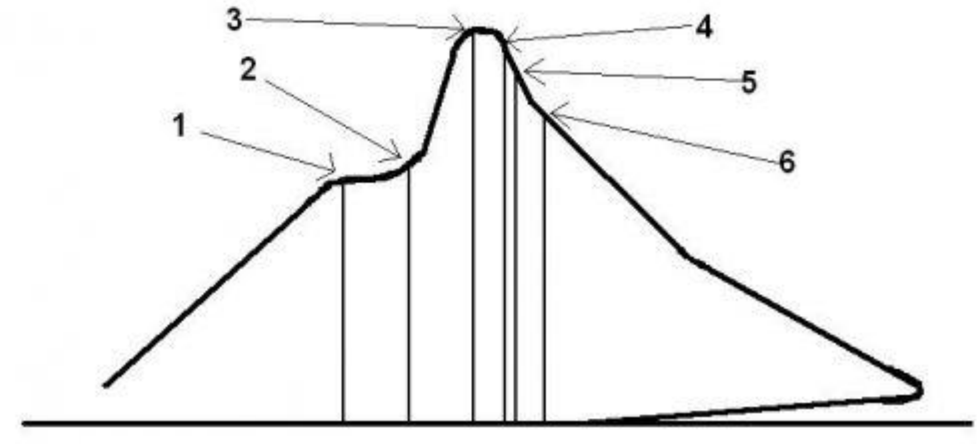


**Fig 4.2 Different Stages of Combustion**

1. Start of Injection
2. Beginning of Ignition
3. Maximum Pressure
4. End of Injection
5. End of Ignition
6. End of After Burning

**Different stages in combustion:**

1-2 : Ignition Delay Period
2-3 : Rapid / Uncontolled combustion
2-4 : Ignition Period
3-4 : Controlled Combustion
5-6 : After Burning

**Third Phase of Combustion:**

Controlled combustion is regulated by the rate at which fuel continues to be delivered.

**After Burning:**

After burning is said to occur when the third phase of combustion extends over a long period. It may be caused by incorrect fuel grade, bad atomization, poor or excess penetration, incorrect fuel temperature, incorrect injection timing, insufficient air supply, or any combination of these. Slow burning, high viscosity, high density, high carbon content fuels may also cause after burning of a serious nature leading to engine damage.

**Effect of After Burning:**

After burning creates high exhaust temperatures and may cause overheating of the engine in severe cases. Some drop in the maximum firing pressure usually accompanies this. There is a loss of thermal efficiency when after burning occurs, due to greater loss of heat to exhaust gases and the transfer of large amount of heat to the cooling water. There is a risk of damage to exhaust valves and scavenge fires.

**4.2 Magnetic Stirrer:**

A magnetic stirrer or magnetic mixer is a laboratory device that employs a rotating magnetic field to cause astir bar (also called “flea”) immersed in a liquid to spin very quickly, thus stirring it as shown in fig 4.6. The rotating field may be created either by a rotating magnet or a set of stationary electro magnets, placed beneath the vessel with the liquid. Since glass does not effect a magnetic field appreciably (it is transparent to magnetism) and most chemical reactions take place in glass vessels (i.e. see beaker (glassware) or laboratory flasks), magnetic stir bars work well in glass vessels. On the other hand, the limited size of bar means that magnetic stirrers can only be used for relatively small (under 4 litres) experiments. They also have difficulty dealing with viscous liquids or thick suspensions. For larger volumes or more viscous liquids, some sort of mechanical stirring is typically needed.

Magnetic stirrers are often used in chemistry and biology. They are preferred over gear-driven motorized stirrers because they are quieter, more efficient, and have no moving external parts to brake or wear out (other than the simple bar magnet itself).Because of its small size, a stirring bar is more easily cleaned and sterilized than other stirring devices. They do not require lubricants which could contaminate the reaction vessel and the product. They can be used inside hermetically closed vessels or systems, without the need for complicated rotary seals. Magnetic stirrers may also include a hotplate or some other means for heating the liquid.

## 4.3 Exhaust Gas analyser

An exhaust gas analyser is an instrument for the measurement of carbon monoxide among other gases in the exhaust, caused by an incorrect combustion The principles used for CO sensors (and other types of gas) are infrared gas sensors and chemical gas sensors. Chemical CO gas sensors with sensitive layers based on polymer have the principal advantage of a very low energy consumption, and can be reduced in size to fit into microelectronic-based systems. On the downside, short- and long term drift effects as well as a rather low overall lifetime are major obstacles when compared with the NDIR measurement principle.[3]When the exhaust gases from the exhaust pipe is sent to 5 gas analyser with the help of a pipe .The 5 gas analyser takes in the gases and measure the percentage of carbion monoxide,carbon di-oxide,hydrocarbons and nitrogen oxides.The 5 gas analyser displays the data on the display screen.

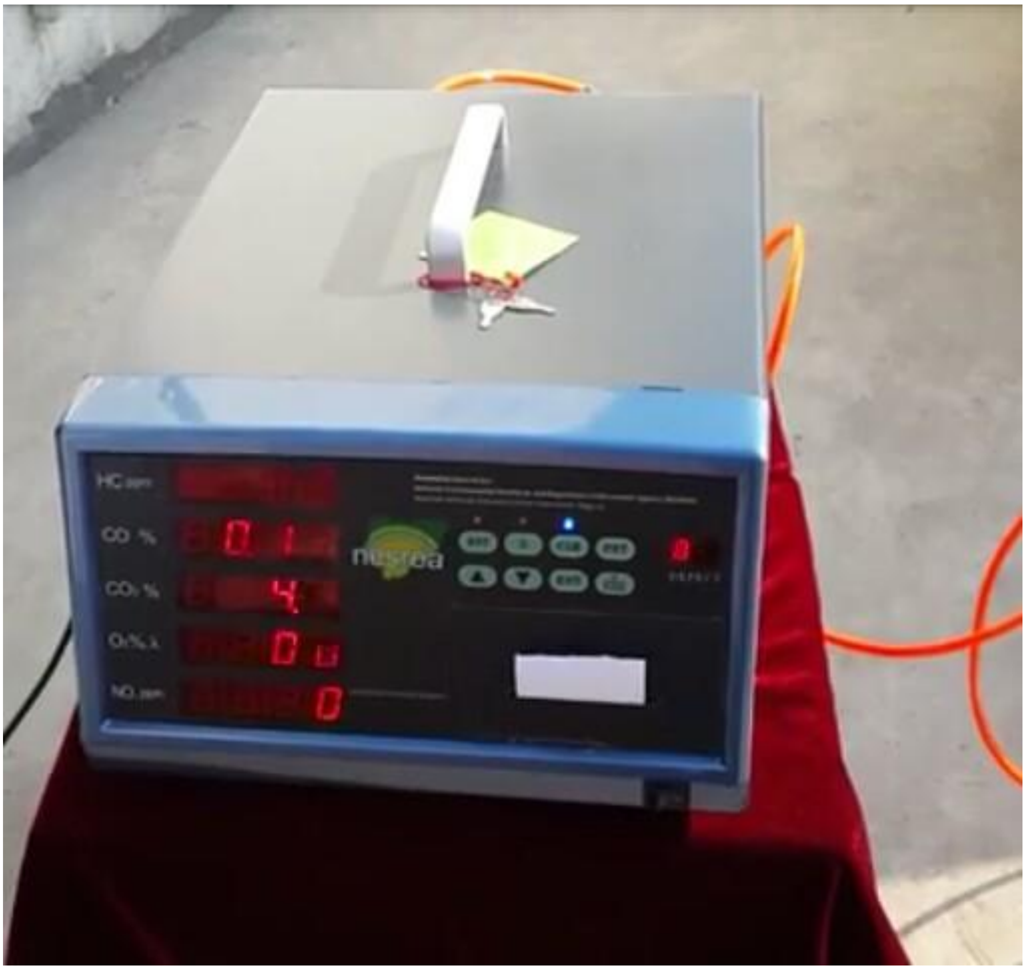

**Fig:4.3 Exhaust Gas Analyser**

**Fig:4.4 Exhaust Pipe clamped to analyser**

# Chapter 5

# Experimental Procedure

# EXPERIMENTAL PROCEDURE

## 5.1 Biodiesel production (transesterification reaction):

Free fatty acid (FFA) value of oil plays key role in the transesterification process. If free fatty acid content of the oil is lower than 3%, single stage process (alkali transesterification) is will be carried out. If it is greater than 3%, double stage process (acid esterification and alkali transesterification) will be carried out.

### 5.1.1 Acid catalyzed esterification process:

500ml of oil (FFA>3%) was taken in clean conical flask. The moisture content of the given oil was removed by heating the oil at 35 to 45°C for 1 hour in magnetic stirrer. After cooling, 60ml of methanol and 3 drops of sulphuric acid was added. It was continuously stirred for 1 hour at 50to 55°C. This mixture was separated for overnight. Top layer consisting of acid esterified oil and bottom layer known as residues were found. The bottom residues layer was separated out from acid esterified oil and used it for biodiesel production.

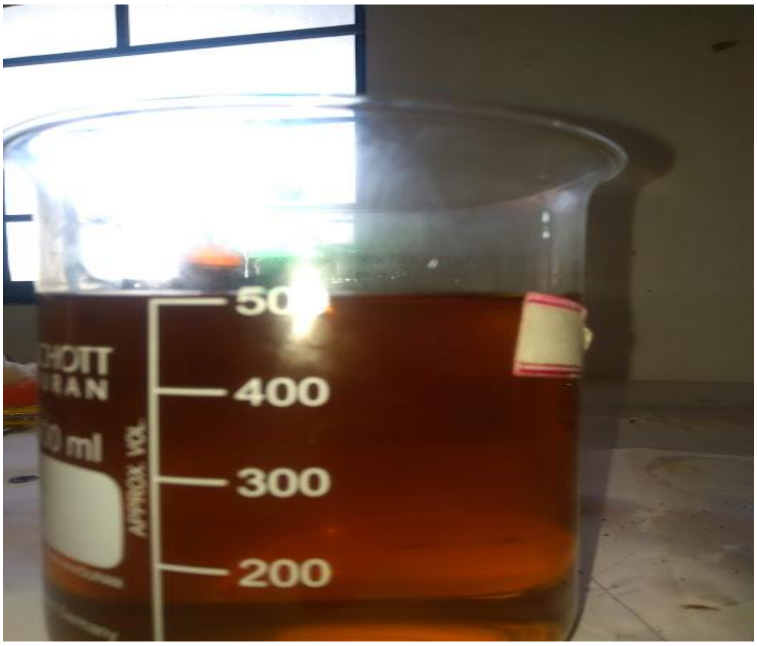


**Fig:5.1 Mahua oil**

### 5.1.2 Sodium hydroxide catalyzed transesterification process:

The bottom layer product of acid esterification was preheated to remove moisture content before starting the reaction. The Sodium hydroxide pillets methanol mixed solution was added to preheated product of the acid esterification. The reaction was conducted at 50°C for 60 min. The resulted product was allowed to settle down under gravity for 8 h in a separating funnel. The products of the Sodium hydroxide transesterification process result in the formation of two layers viz., an upper layer containing biodiesel (methyl ester) and lower layer containing glycerol.

In general Biodiesel is used as a blend component and added to diesel.At present in brazil they are using B5, it means that in 1 liter of diesel 50 ml of biodiesel is mixed.In our project we used three types of blends B5,B10,B20.By using B5,B10,B20 as fuel we conducted various tests on vertical diesel engine and calculated various parameters such as indicated power,brake specific fuel consumption,fuel consumption,emission parameters such as percentage of carbon monoxide,carbondioxide,hydrocarbons,nitrogen oxide are calculated.

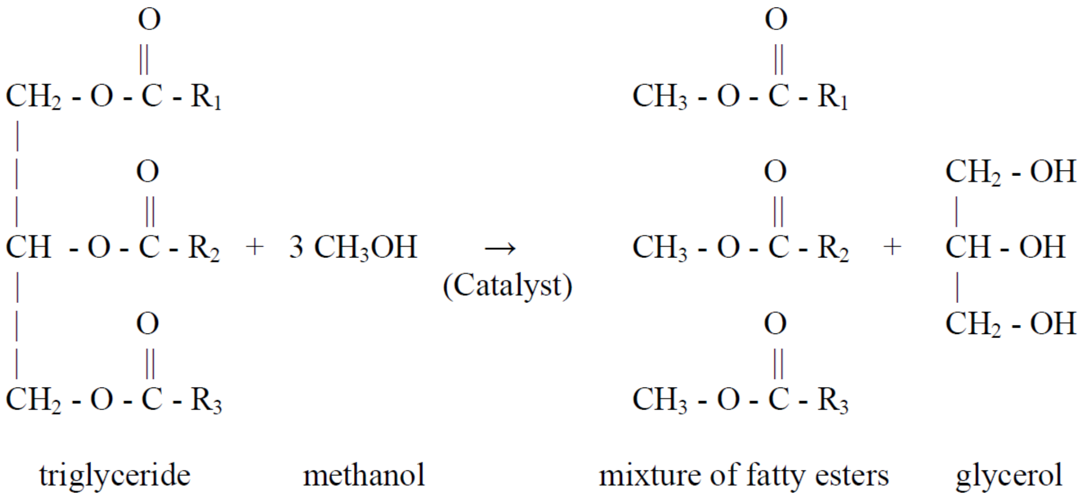


**Fig:5.2 Transesterification Reaction**


**Fig: 5.3  Electrical Heater with Magnetic Stirrer**

**Draining Glycerol**

After Transesterification process we would get glycerol which has higher density than mahua methyl ester settles down in separating collector .Now we collect that glycerol in beaker by opening the valve present to that seperating collector.

**Fig:5.4 Draining Glycerol**

**Fig:5.5 Removal of excess soap**

Water is added to biodiesel and mixed vigorously which would collect excess glycerine at the bottom as the water has higher density than ester.The process is done until the separation of biodiesel and distilled water appears to be crystal clear in order to remove the soap solution left after draining glycerol.

**Procedure at Engine**

At present in brazil they are using B5, it means that in 950 liter of diesel is mixed with 50 ml of biodiesel to give one litre sample.In our project we used three types of blends B5,B10,B20. Initially one litre of B5 Biodiesel is poured in diesel engine tank and the oil is sent into engine cylinder with the help of pipes. When the engine starts combusion takes place and they are sent out of cylinder through exhaust valve.The exhaust gases are collected from the exhaust pipe and sent into 5 gas analyser.The exhaust gas analyser analyse the gases and display the data on the reciever.

# CHAPTER 6

# CALCULATIONS

# CALCULATIONS

## 6.1 Basic Data

1. Rated brake power of engine B.P = 5 H.P = 3.7KW
2. Speed of engine N = 1500rpm
3. Effective radius of the brake drum R = 0.213 m
4. Stroke length L =$110\times10^{-3}$ m
5. Diameter of cylinder bore D = $80\times10^{-3}$ m
6. Time taken for 10cc consumption of fuel is 't' sec

## 6.2 Basic Calculations:

Fuel consumption (F.C) $= \frac{10\times sp.gravity\ \times3600}{t\times1000}$

Brake power (B.P) $= \frac{2\pi N\,(W-S)\times9.81\times R}{60000}$

Specific fuel consumption (S.F, C) $= \frac{F.C}{B.P}$

Brake thermal efficiency ($\eta_{Bth}$) $= \frac{B.P\times3600}{FC\times CV}$

## 6.3 Model Calculations:

### 6.3.1. Pure Diesel

Brake power (B.P) $= \frac{2\pi N\,(W-S)\times9.81\times R}{60000}$

$= \frac{2\pi\times1500\times2.8\times9.81\times0.218}{60000}$

= 0.917KW

Fuel consumption (F.C) $= \frac{10}{t}\times\frac{specific\ \ gravity\ \times3600}{1000}$kg/hr

= (10/49.2)×$\frac{0.82\times3600}{1000}$kg/hr

=0.6kg/hr

Specific fuel consumption (SFC) $= \frac{F.C}{B.P}$kg/KW-hr

$=\frac{0.6}{0.917}$

= 0.654 kg/KW- hr

Brake thermal efficiency $\eta_{Bth}$ $=\frac{B.P\times3600}{FC \times CV}$

` $=\frac{0.917\times3600}{0.6 \times 45500}$

= 12%

**6.3.2. Calculations of Biodiesel blend 5**

Brake power (B.P) $=\frac{2\pi N\,(W-S)\times9.81\times R}{60000}$

$=\frac{2\pi\times1500\times2.8\times9.81\times0.218}{60000}$

=0.917 KW

Fuel consumption (F.C) $=\frac{10}{t}\times\frac{specific\ \ gravity\ \times3600}{1000}$kg/hr

=(10/47.73)×$\frac{0.822\times3600}{1000}$kg/hr

=0.62kg/hr

Specific fuel consumption (SFC) $=\frac{F.C}{B.P}$kg/KW-hr

$=\frac{0.62}{0.917}$

=0.66 kg/KW -hr

Brake thermal efficiency $\eta_{Bth}$ $=\frac{B.P\times3600}{FC \times CV}$

$=\frac{0.917\times3600}{0.62 \times 45000}$

= 11 %

**6.3.3. calculations of blend 10**

Brake power (B.P) $=\frac{2\pi N\,(W-S)\times9.81\times R}{60000}$

$=\frac{2\pi\times1500\times2.8\times9.81\times0.218}{60000}$

$=0.917$ KW

Fuel consumption (F.C) $=\frac{10}{t}\times\frac{specific\ \ gravity\ \times 3600}{1000}$kg/hr

$=(10/46.35)\times\frac{0.824\times 3600}{1000}$kg/hr

$=0.64$kg/hr

Specific fuel consumption (SFC) $=\frac{F.C}{B.P}$kg/KW-hr

$=\frac{0.64}{0.917}$

$=0.676$ kg/KW -hr

Brake thermal efficiency $\eta$Bth $=\frac{B.P\times 3600}{FC\times CV}$

$=\frac{0.917\times 3600}{0.64\times 44900}$

$= 11\%$

**6.3.4. Calculations of Biodiesel blend 20**

Brake power (B.P) $=\frac{2\pi N\,(W-S)\times 9.81\times R}{60000}$

$=\frac{2\pi\times 1500\times 2.8\times 9.81\times 0.218}{60000}$

$=0.917$ KW

Fuel consumption (F.C) $=\frac{10}{t}\times\frac{specific\ \ gravity\ \times 3600}{1000}$kg/hr

$=(10/38.21)\times\frac{0.828\times 3600}{1000}$kg/hr

$=0.78$kg/hr

Specific fuel consumption (SFC) $=\frac{F.C}{B.P}$kg/KW-hr

$=\frac{0.78}{0.917}$

$=0.85$ kg/KW –hr

Brake thermal efficiency $\eta$Bth $=\frac{B.P\times 3600}{FC\times CV}$

$=\frac{0.917\times 3600}{0.78\times 44800}$ $= 9\%$

### 6.4 Tables

#### 6.4.1 Observations of Pure Diesel

During the experimentation we got some values .From those we found other terms like Brake Power, Fuel Consumption , Brake Specific Fuel Consumption, Brake Thermal Efficiency

**Table 6.1:Observations of pure diesel**

| Sl.No | Load(kg) W-S | Time(sec) | Brake Power(KW) | Fuel Consumption(Kg/hr) | BSFC(Kg/KW-hr) | Brake Thermal Efficiency(%) |
|---|---|---|---|---|---|---|
| 1 | 0 | 73.8 | 0 | 0.4 | - | 0 |
| 2 | 2.8 | 49.2 | 0.917 | 0.6 | 0.654 | 12 |
| 3 | 5.8 | 36.9 | 1.90 | 0.8 | 0.421 | 18 |
| 4 | 8.8 | 30.1 | 2.88 | 0.98 | 0.340 | 23 |
| 5 | 11.8 | 24.8 | 3.86 | 1.19 | 0.308 | 25 |

#### 6.4.2 Observations of BioDiesel Blend 5

**Table 6.2:Observations of B5**

| Sl.No | Load(kg) W-S | Time(sec) | Brake Power(KW) | Fuel Consumption(Kg/hr) | BSFC(Kg/KW-hr) | Brake Thermal Efficiency(%) |
|---|---|---|---|---|---|---|
| 1 | 0 | 58 | 0 | 0.51 | - | 0 |
| 2 | 2.8 | 47.73 | 0.917 | 0.62 | 0.66 | 11 |
| 3 | 5.8 | 36.1 | 1.90 | 0.82 | 0.431 | 18 |
| 4 | 8.8 | 29.6 | 2.88 | 1 | 0.347 | 23 |
| 5 | 11.8 | 24 | 3.86 | 1.23 | 0.32 | 25 |

### 6.4.3 Observations Of Biodiesel Blend 10

**Table 6.3:Observations of B10**

| Sl.No | Load(kg) W-S | Time(sec) | Brake Power(KW) | Fuel Consumption(Kg/hr) | BSFC(Kg/KW-hr) | Brake Thermal Efficiency(%) |
|---|---|---|---|---|---|---|
| 1 | 0 | 49.4 | 0 | 0.6 | - | 0 |
| 2 | 2.8 | 46.35 | 0.917 | 0.64 | 0.676 | 11 |
| 3 | 5.8 | 35.31 | 1.90 | 0.84 | 0.442 | 17 |
| 4 | 8.8 | 26.97 | 2.88 | 1.1 | 0.3819 | 20 |
| 5 | 11.8 | 23.17 | 3.86 | 1.28 | 0.332 | 24 |

### 6.4.4 Observations Of Biodiesel Blend 20

**Table 6.4:Observations of B20**

| Sl.No | Load(kg) W-S | Time(sec) | Brake Power(KW) | Fuel Consumption(Kg/hr) | BSFC(Kg/KW-hr) | Brake Thermal Efficiency(%) |
|---|---|---|---|---|---|---|
| 1 | 0 | 42.58 | 0 | 0.7 | - | 0 |
| 2 | 2.8 | 38.21 | 0.917 | 0.78 | 0.85 | 9 |
| 3 | 5.8 | 31.05 | 1.90 | 0.96 | 0.505 | 15 |
| 4 | 8.8 | 24.84 | 2.88 | 1.2 | 0.416 | 19 |
| 5 | 11.8 | 19.87 | 3.86 | 1.5 | 0.389 | 21 |

# CHAPTER 7

# RESULTS AND DISCUSSION

## RESULTS AND DISCUSSION

The basic engine performance measuring parameters are Brake Thermal Efficiency, Fuel Consumption and Brake Specific Fuel Consumption has been obtained from different blends and results are compared with pure diesel.

### 7.1 Effect of brake power on Brake Thermal Efficiency:

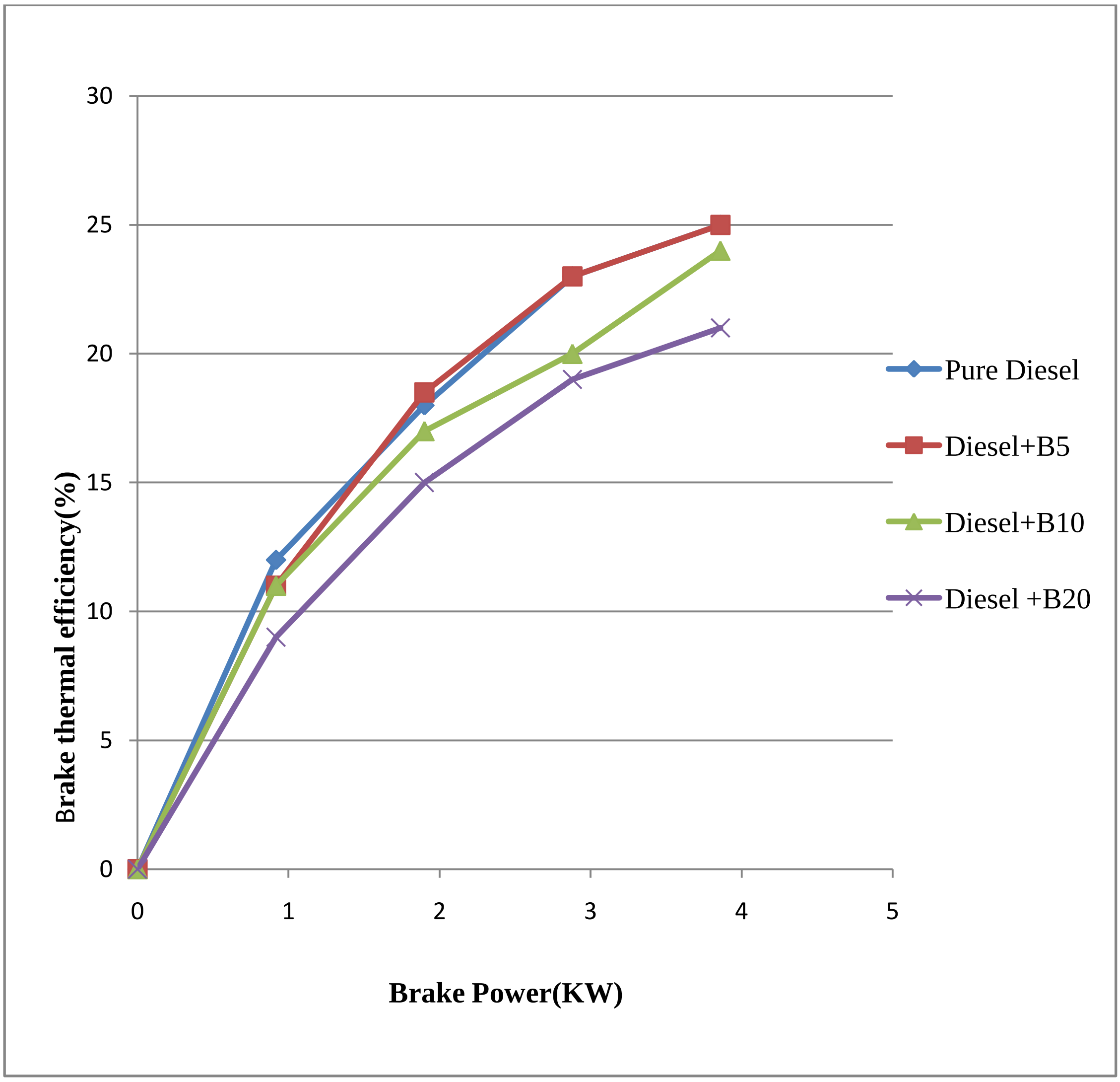


**Figure 7.1 Effect of BP on brake thermal efficiency when diesel engine has run on B5, B10, B20 and diesel.**

Figure 3.1 shows the variation of BP on brake thermal efficiency when diesel engine has run on B5, B10 and B20 respectively. The figure shows that with increase in the brake power brake thermal efficiency also increases. It is observed that Mahua biodiesel blend B5 have brake thermal efficiency is close to diesel. Brake thermal efficiency is decreases in percentage of biodiesel blends.

### 7.2 Effect of brake power on Brake specific fuel consumption:

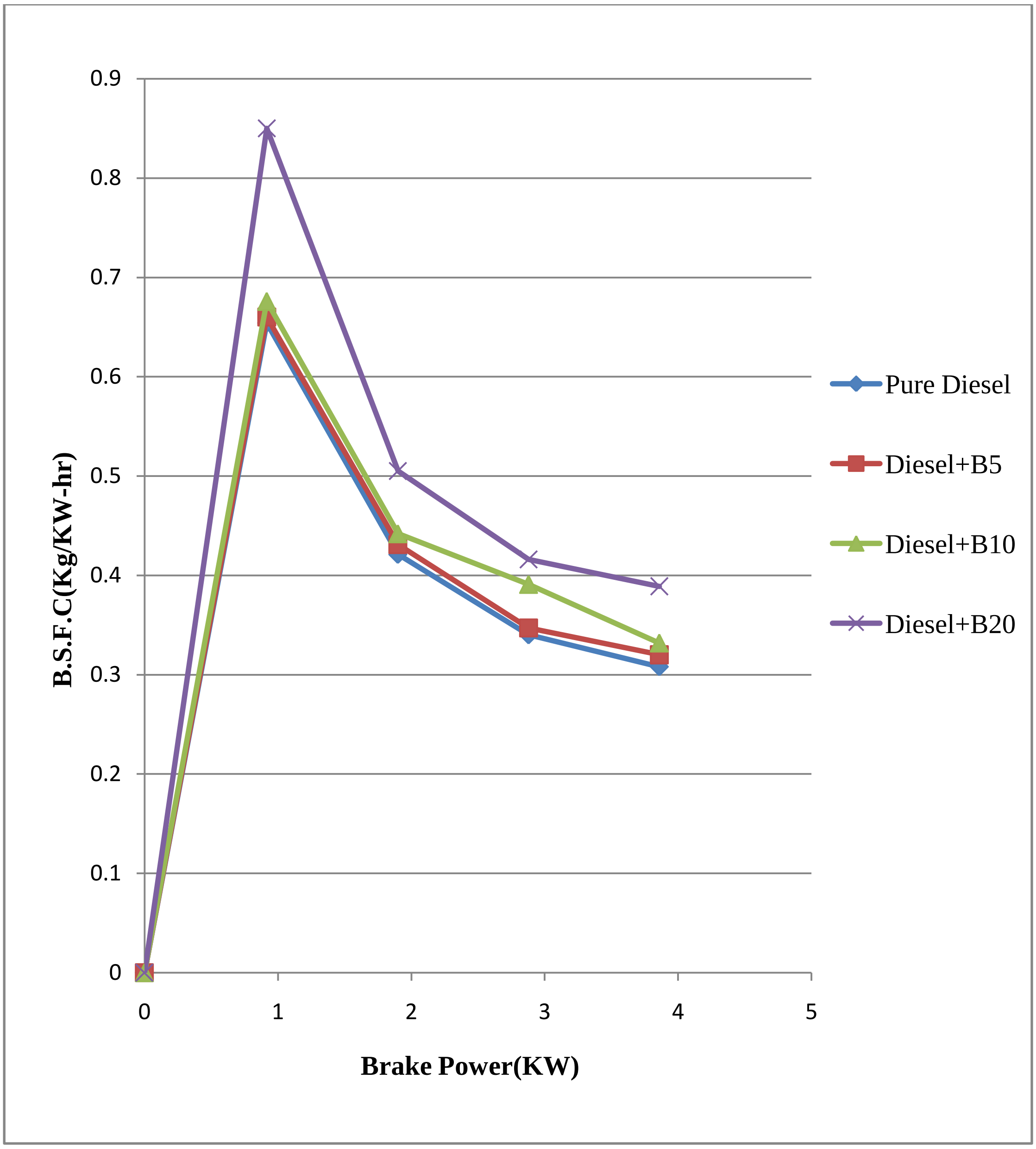


**Figure 7.2 Effect of BP on brake specific fuel consumption when diesel engine has run on B5, B10, B20 and diesel.**

Figure 3.2 shows the variation of BP on brake specific fuel consumption when diesel engine has run on B5, B10 and B20 respectively. The figure shows that with increase in the brake power brake specific fuel consumption decreases. It is observed that Mahua biodiesel blend B5 and B10 have Brake specific fuel consumption is close to diesel. Brake specific fuel consumption is increases in percentage of biodiesel blends.

**7.3 Effect of brake power on fuel consumption:**

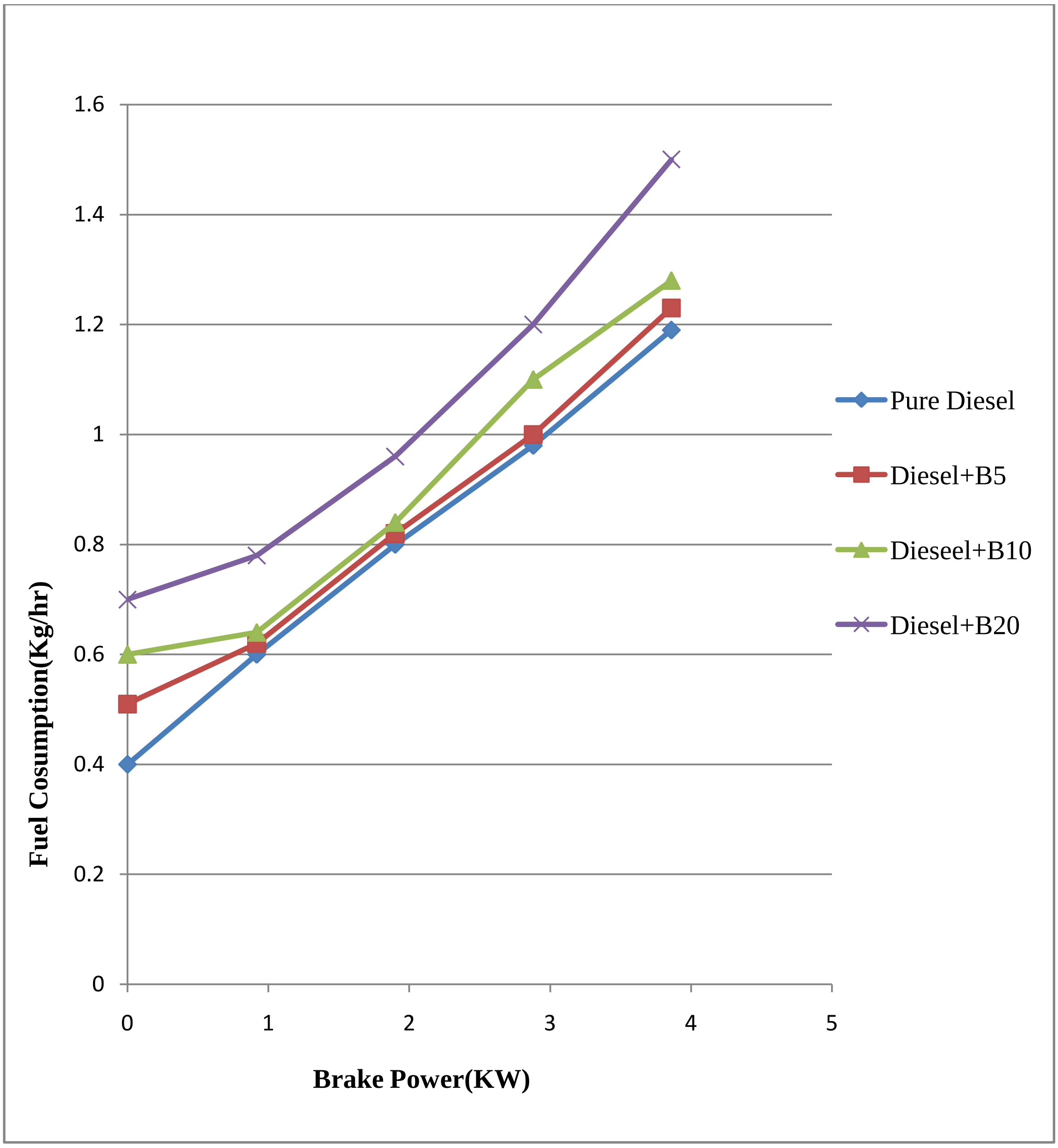


**Figure 3.3 Effect of BP on fuel consumption when diesel engine has run on B5, B10, B20 and diesel.**

Figure 3.3 shows the variation of BP fuel consumption when diesel engine has run on B5, B10 and B20 respectively. The figure shows that with increase in the brake power fuel consumption also increases. It is observed that Mahua biodiesel blend B5 and B10 have fuel consumption is close to diesel fuel consumption is increases in percentage of biodiesel blends.

**7.4 Effect of load on carbon monoxide:**

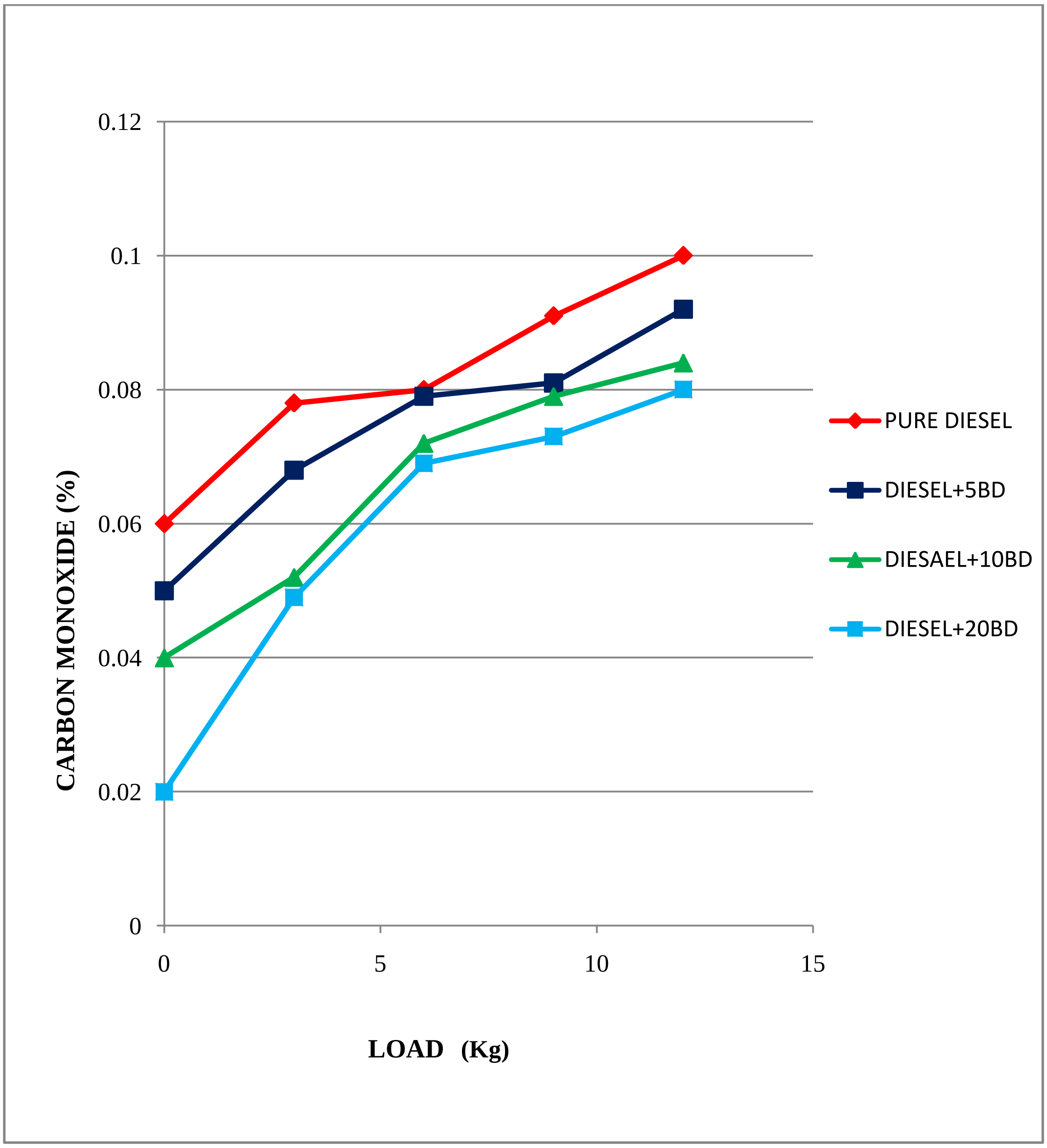


**Figure 3.4 Effect of load on carbon monoxide emission when diesel engine has run on B5, B10, B20 and diesel.**

Figure 3.4 shows the effect of load on CO emission when diesel engine runs on B5, B10, B20 and diesel. From figure 3.4 CO emissions increasing with increasing the load and decreases with increasing the ester. CO emission increases with load starting from no load for all fuels. The CO emission decreases with increasing percentage of blends.

### 7.5 Effect of load on carbon dioxide:

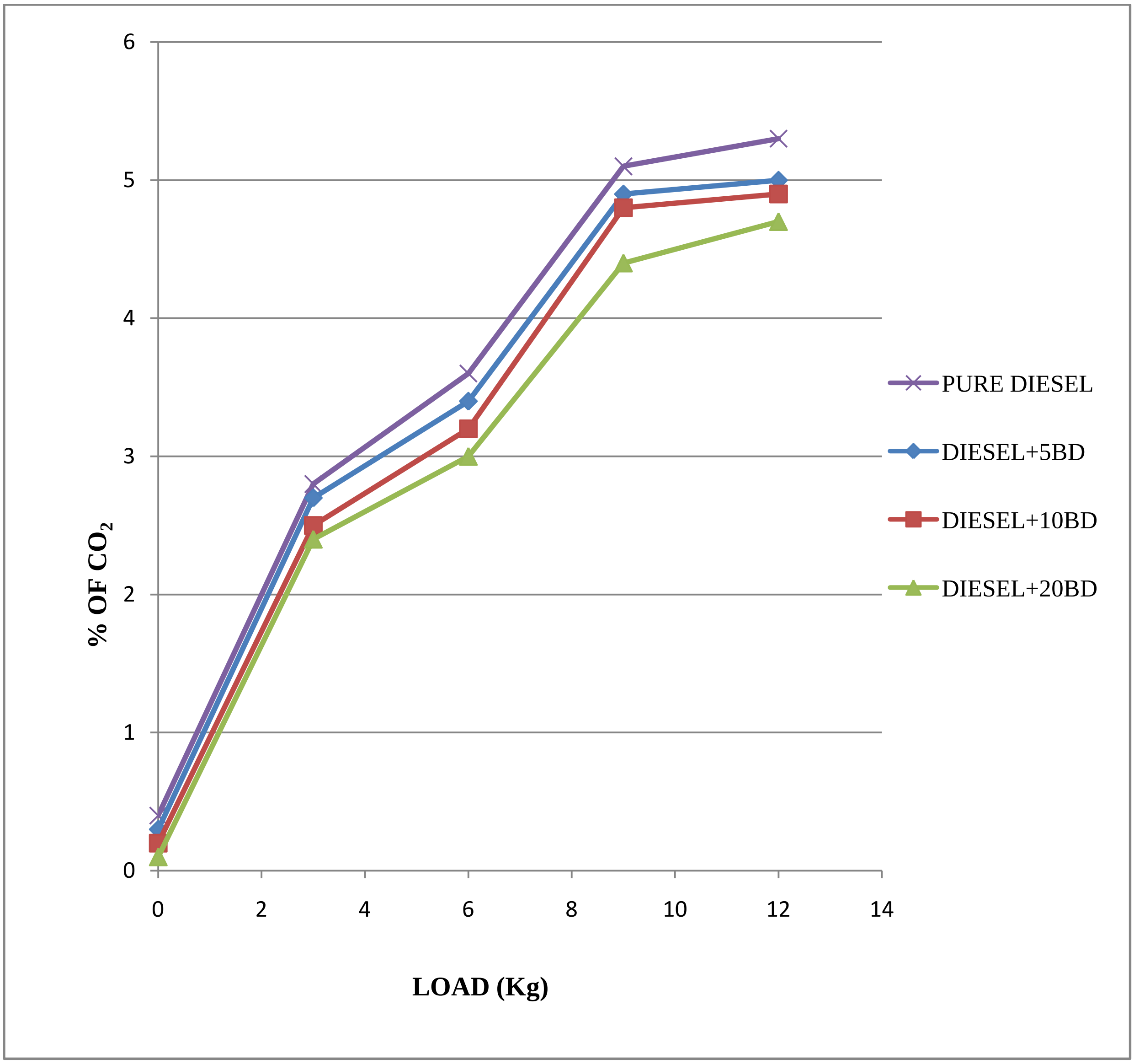


**Figure 7.5 Effect of load on carbon dioxide emission when diesel engine has run on B5, B10, B20 and diesel.**

Figure 3.5 shows the effect of load on $CO_2$ emission when diesel engine runs on B5, B10, B20 and diesel. The carbon dioxide is gradually increases with increasing the load for all blends. The lower percentage of Mahua methyl ester blends emits less amount of $CO_2$ in comparison with diesel. Blend B20 emits very lower emission shown in figure.

**7.6 Effect of load on hydrocarbons:**

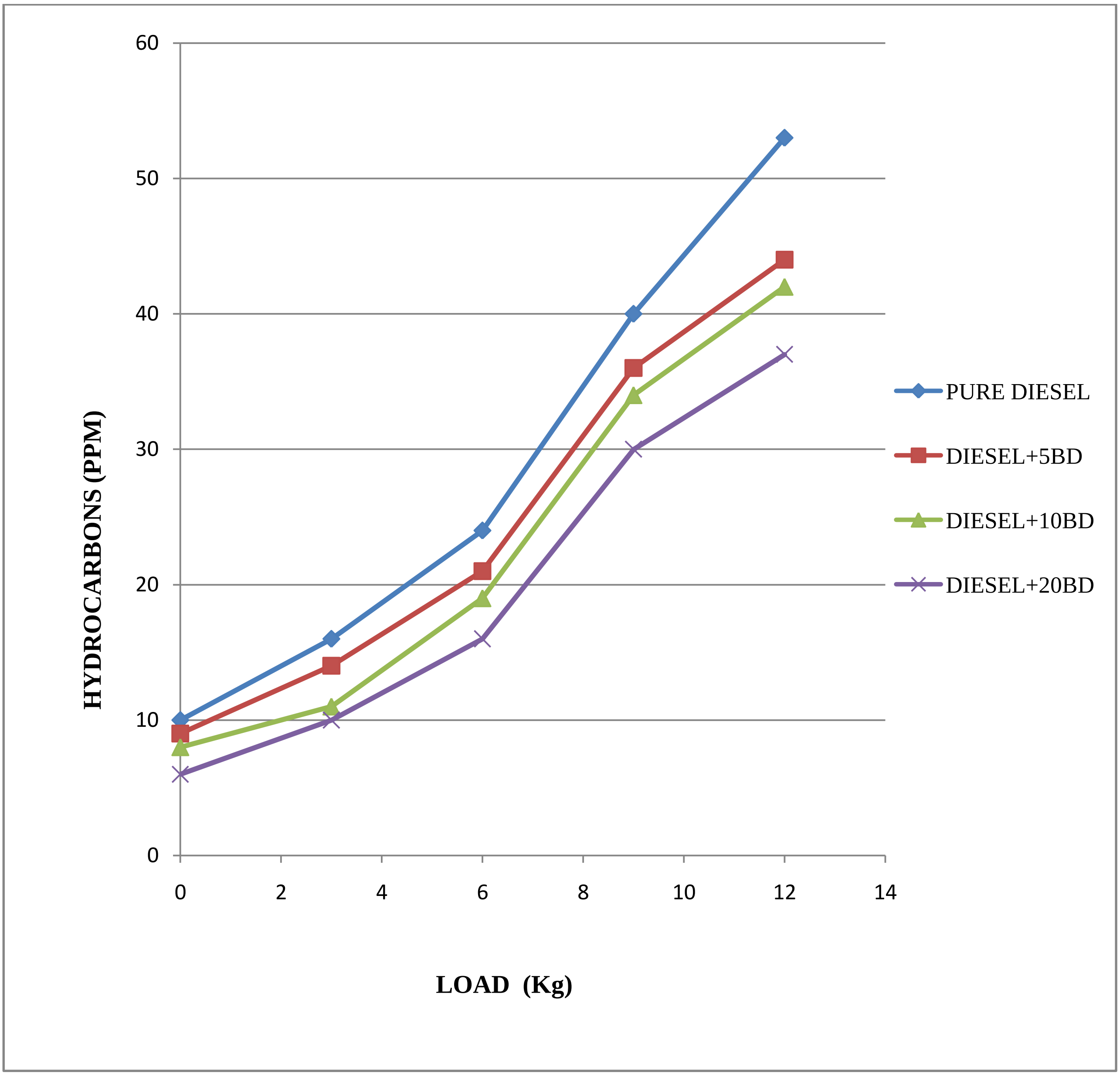


**Figure 7.6 Effect of load on hydrocarbon emission when diesel engine has run on B5, B10, B20 and diesel.**

Figure 3.6 shows the effect of load on hydrocarbon emission when diesel engine runs on B5, B10, B20 and diesel. It shows that HC emission increases with the increasing load and decreases with increase in percentage of ester. B20 has minimum HC emission at all loads. B5 has maximum HC emission at all the loads.

**7.7 Effect of load on $NO_X$ emission:**

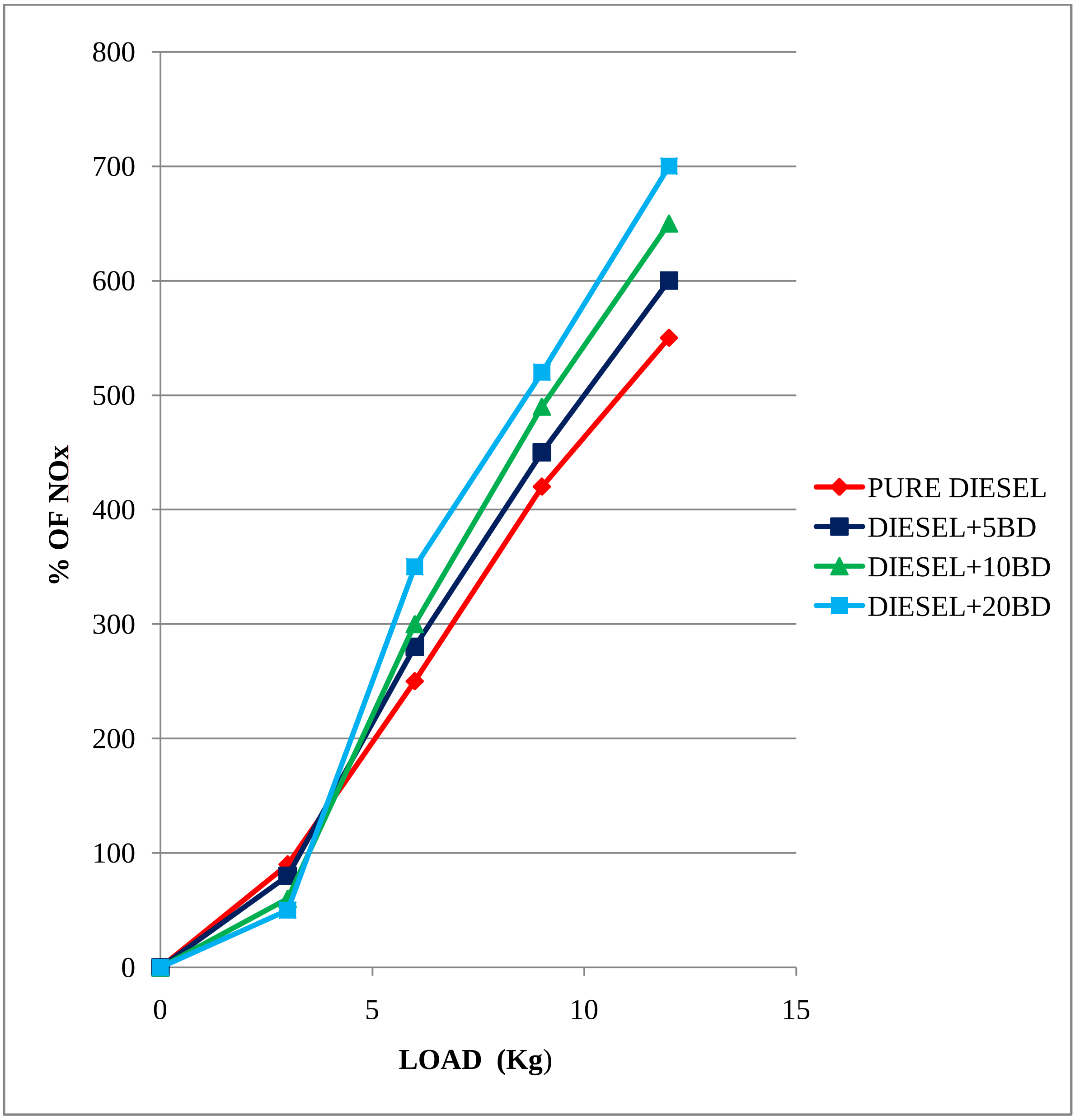


**Figure 7.7 Effect of load on Nitrogen oxide emission when diesel engine has run on B5, B10, B20 and diesel.**

Figure 3.7 shows the effect of load on $NO_X$ emission when diesel engine runs on B5, B10, B20 and diesel. Figure 3.7 shoes that $NO_X$ increases with increase in the percentage of ester. B5 have minimum $NO_X$ emission. The primary reason of higher $NO_X$ emiossion of mahua oil biodiesel fuel is contributed towards inbuilt oxygen

# CHAPTER 8

# CONCLUSION

# CONCLUSION

- Mahua oil can be successfully converted into methyl ester by using transesterification process and this process reduces the properties like viscosity, flash point, calorific value of mahua methyl ester.
- The Experimental study is conducted to evaluate and compare the blends of mahua oil to conventional diesel in single cylinder naturally aspirated vertical diesel engine.
- The series of tests are conducted using each of fuels with the engine working at a constant speed of 1500 rpm and at different loads starting from no load. In each test fuel consumption, brake specific fuel consumption, brake thermal efficiency and emission of CO, $CO_{2,}$ Hydrocarbons and $NO_x$.
- Brake thermal efficiency, Fuel consumption and brake specific fuel consumptions are close to the pure diesel for blends B5 and B10.
- From the performance characteristics it is observe that the percentage of CO, $CO_2$ are reduces with increasing the percentage of ester.

It is finally concluded that B5 blend offers the best performance by taking parameters like specific fuel consumption and emission of carbon monoxide and carbon dioxide.

# CHAPTER 9

# REFERENCES

# REFERENCES

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Chatpalliwarletal described the brief overview of the Biodiesel production plant.Various issues-sources, opportunities, challenges, plant design and evolution etc, are discussed related to the biodiesel production.

Godignur et al (2009) carried out an experimental investigation to study the performance and emission characteristics in a turbocharged direct injection compression ignition engine fuelled with diesel, Mahua oil biodiesel, and its blends

K.Anbumani and ajit pal singh observed the feasibility of using two edible plant oils mustard and neem as diesel substitute a comparative study on their combustion cheracteristics on a C.I. Engine were made.

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Md.ImranKaisetal research focused on algae cultivation.A lab scale production of Chlorella and Botroyococcusbraunii was executed in open pond and Bioreactor system.Then diesel was produced by transesterification from collected algae oil.Later data was collected from this experiment Bull, S.R.Renewable energy transportation technologies.

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